

DEC. 1948

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 CENTRAL INTELLIGENCE AGENCY REPORT
 INFORMATION FROM
 FOREIGN DOCUMENTS OR RADIO BROADCASTS CD NO.

50X1-HUM

COUNTRY USSR
 SUBJECT Scientific - Chemistry - Laboratory equipment
 HOW PUBLISHED Monthly periodical
 WHERE PUBLISHED Moscow
 DATE PUBLISHED Apr 1950
 LANGUAGE Russian

DATE OF INFORMATION 1950

DATE DIST. 4 Aug 1950.

NO. OF PAGES 3

SUPPLEMENT TO REPORT NO.

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SOURCE Zavodskaya Laboratoriya, Vol XVI, No 4, 1950.

A SOVIET DEVICE FOR DETERMINING THE VAPOR DIFFUSION
COEFFICIENT OF LIQUIDS IN THE ATMOSPHERE

B. V. Deryagin
 P. S. Prokhorov
 A. D. Malkina
 Inst of Phys Chem
 Acad Sci USSR

In the measurement of various liquids' vapor diffusion coefficients, many laboratories are using methods of the last century. Most of these methods entail great difficulties in experimentation and a waste of time in the measuring process.

The apparatus which we have developed for the determination of diffusion coefficients is based on the measurement of a very small difference in pressure on the two sides of a porous partition. This difference is proportional to the diffusion rate.

The method permits determination of the diffusion rate by direct readings on a manometer.

The basic part of the device is a plate 10-15 millimeters thick with pores 1-3 microns wide. This plate serves as a partition separating a cylindrical vessel into an upper and a lower chamber. The liquid under investigation is fed into the lower chamber through a tube which is supplied from a funnel. Flow is controlled by a three-way cock.

The vapor from the liquid in the lower chamber saturates the lower space while a flow of air or gas into the upper chamber maintains the vapor tension at zero or any value less than the vapor tension of the saturated vapor.

It follows, then, that in the stationary state between the two chambers, a pressure drop is established proportional to the difference in the partial vapor tensions on both sides of the partition. An ordinary U-shaped differential manometer is used to measure the pressure drop. Since tinted dibutyl

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phthalate has a very low vapor tension, it is used as the manometric liquid. In cases when partial vapor tension and pressure drop are small, the sensitivity of the manometer reading must be increased; a manometer with an air bubble may be used for this.

Let us suppose that the chambers of the device contain only the vapors of the liquid being investigated. The flow of gas (vapor) from the lower chamber through the pores of the partition will be determined by the viscosity of the vapor, and the rate of flow through the pores, other conditions being equal, will be constant. But if, in addition to the vapors of the given liquid or gas, there is a second gas (in this case, air), then two processes will take place. The first process will consist in the diffusion of the vapors of the supplied liquid to the outside of the chamber, and diffusion of the air in the opposite direction as a result of the difference in the concentrations. The second process is connected with the hydrodynamic flow of the air-vapor mixture through the pores of the partition. Comparing the two processes and disregarding radial pressure in the pores we have:

$$D' \frac{dC'}{dh} \alpha = \frac{\beta}{\eta} C' \frac{dP}{dh}, \quad (1)$$

where D' is the diffusion coefficient of the gas through the vapor, C' is the molar concentration of the gas (air), α is a coefficient dependent upon the partition's porosity, β is the filtration coefficient in Darcy's law, η is the viscosity of the vapor-gas mixture, P is hydrostatic pressure, and h is the height of the porous partition.

Dividing (1) termwise by C' , integrating (η - constant), and transferring from concentrations to partial pressures, we obtain:

$$D' \lg \frac{p'_0}{p'_1} = \frac{\beta}{\alpha} \frac{\Delta P}{\eta}$$

or

$$\begin{aligned} D' \lg \left(\frac{P_0 - p_0}{P_1 - p_1} \right) &= \\ &= \left(\frac{P_1 - P_0}{\eta} \right) \end{aligned} \quad (2)$$

where p_0 and p_1 are vapor tensions above and below the partition, respectively, and P_0 and P_1 are the pressures above and below the partition. In most cases, the following simplified formula will apply:

$$\begin{aligned} D(P_1 - P_0) &= \frac{\beta}{\alpha} \frac{\Delta P \cdot P_0}{\eta} = \\ &= K \frac{P_0 \Delta P}{\eta}. \end{aligned} \quad (3)$$

This formula may be used for calculating the diffusion coefficient D when vapor tension p_1 of the substance, and the constant of the device K are known, since the vapor tension p_0 may easily be made equal to zero by causing uninterrupted motion of the air current over the surface of the partition. In most cases it is possible to use for η a value corresponding to the pure gas or the

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air which fills the upper chamber. The constant of the device is determined by using a liquid the diffusion coefficient D and vapor tension p_1 of which are known.

Test results for acetone, benzene, methyl alcohol, and carbon tetrachloride at temperatures of 0 and 20 degrees centigrade corresponded very closely to values already established for these substances.

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